

Personal Air Vehicles (PAVs), Their Airspace Implications, And Relationship To UASs

Andrew Hahn

Safety of Unmanned Aircraft Systems

April 29, 2008

Why am I here?

Air & Space Smithsonian Article by Mark Gatlin

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FLIGHT TODAY

My Other Car Is a Podcopter

Bumper sticker in the year 2015? 2025? Ever?

By Mark Gatlin
Air & Space Magazine, January 01, 2008



A NASA program that ended in 2005 generated little more than this artist's conception of the perfect easy-to-fly personal air car.

(NASA Langley)

You head out the door and down to the street to catch your ride to work. The aircraft is waiting. The only sound is the low hum of ducted fans at the rear.

Where you'd once expected a pilot, there is instead a panel of

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Air & Space Smithsonian Article (1)

- Bushnell Predictions (LaRC Chief Scientist)
 - ... ability to create an autonomous robotic vehicle will be possible “very soon.”
 - The initial personal air vehicle probably won’t be inhabited ... It will be a civilian version of a military UAV to do robotic package delivery. (e.g. unmanned pizza delivery pod)
 - Commuter version: “Think of unmanned aerial vehicles with humans as cargo,” Bushnell says. He envisions an air vehicle that can also drive on the ground, yet still costs less than \$50,000. “It will not fly high and not very fast—say, 120 knots [138 mph]—and feature a two-passenger climate-controlled cockpit.”
 - ... will employ super-short takeoff and landing. “You need something that will take off on the 50 to 70 feet of street in front of your house.”

Air & Space Smithsonian Article (2)

- Hahn Predictions (PAV Deputy Sector Manager)
 - “The automation will undoubtedly get better,” he says. “When the automation gets really good, we may allow the automation to fly without people, over lightly populated areas, but I don’t see high-energy UAVs flying fully autonomously in heavy traffic and over cities for a long, long time.”
 - “From the manufacturers’ standpoint, aircraft are low-volume and high-liability, which quite frankly scares them to death,” notes Hahn. “From the average person’s viewpoint, they are unobtainable, dangerous, hard-to-use toys that are really annoying. As long as both parties believe this, the answer [to when personal air vehicles will fly] will be ‘never.’ ”
- Ballin Predictions (Aviation Operations)
 - “Fully automated air traffic management is still many years off—perhaps more than 50.”

Air & Space Smithsonian Article (3)

- Factual Errors

- no drive-fly vehicle designs have ever been submitted to the Federal Aviation Administration for certification. (Taylor Aerocar & Fulton Airphibian)
- Many personal air vehicle proponents see ducted fans as the solution, since they are quieter and lighter than either propellers or rotors.
- The NASA team at Langley developed two systems intended to develop sentient vehicles that could offer, according to a NASA report, “fully autonomous flight” for a lone pilot in nearly all weather “with confidence and relative ease.” In the report, the pilot-craft relationship is compared to more familiar partnerships: “The pilot guides the personal air vehicle with the control stick and the [onboard programming, reacting to the pilot’s actions] negotiates turbulent air as best it can, just as a rider guides through the reins and the horse negotiates rough terrain.” If the pilot is distracted or makes a mistake, the computer vibrates the stick to alert him.

What Is a PAV?

EQuiPT: Easy-to-Use, Quiet Personal Transportation

Ease-of-Use Equivalent to Automobiles

- Intuitive, user-friendly haptic control suite with flight control guidance

Good Neighbor Operations

- Quiet engines and propulsors
- Auto equivalent emissions

Fast, On-Demand Travel

- Increases accessibility across U.S. to 10,000+ airport destinations
- Reduces travel time compared to auto and airline for 25-500 miles

Widespread Public Affordability

- Pilot training cost reduced by 10x
- Purchase price reduction 4x
- Shared ownership \$/mile cost equivalent to automobile



Ease-of-Use: Haptic Control System

- PAV Sector Cut when NASA Aeronautics was Reorganized in 2006
- Number One PAV Priority (\$24/32M Budgeted)
- Haptic control interface (H-mode) is a new control architecture (can most easily be thought of as Horse mode)
- H-mode Fully redundant digital flight control
- Not simply autonomous
- Workload and situational awareness is shared and communicated between pilot and the aircraft under normal operations
- H-mode provides feedback when pilot deviates from safe or authorized operation
- Can act in an emergency and immediate feedback acts as robotic copilot/Instructor
- **Highly leverages UAV research and deployment**
- Probably won't meet low cost goal near term, but is a much longer term solution

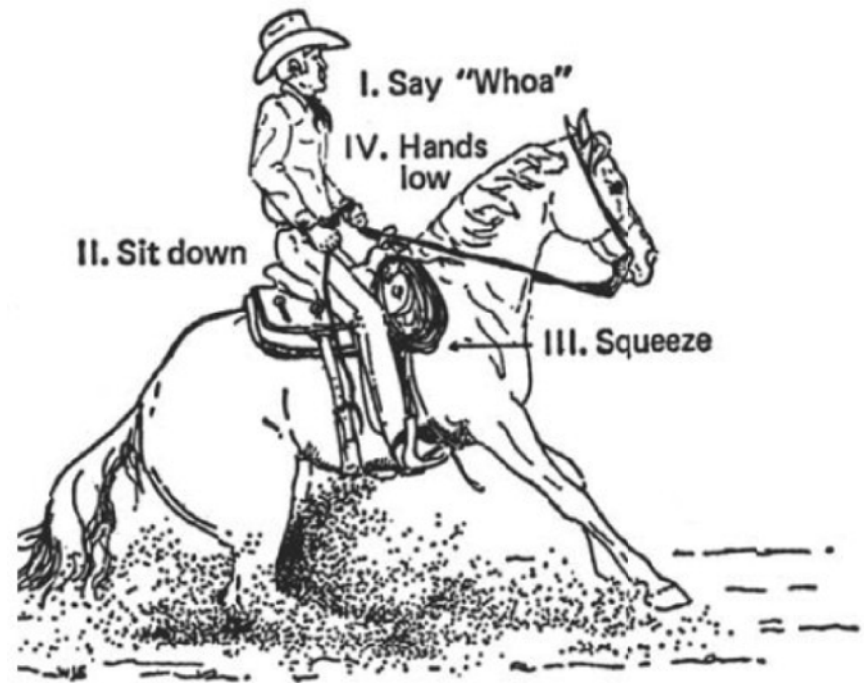


Figure 8 – Stopping (Western Equestrian)
(Miller, 1975)

Ease-of-Use: New Display Technologies

- We need a more near-term, affordable option for Ease-of-Use as well
- Need to completely rethink the role of instrumentation
- VFR requires very little instrumentation
 - Most flight critical information acquired by looking outside
- IFR should be just as easy
 - No new skills, no modal changes
 - Information should be filled in when missing, but pilot still looks “outside”
 - Requires focused human factors based design and testing
- Do not cater to pilots
 - Pilots have already paid the price of training, influencing their preferences
 - Ex: when glass cockpits were introduced, pilots wanted pictures of “steam gauges”



Pressure for UAVs in the Airspace Mounting

- DATE:02/04/08, SOURCE:Flight International, By Arie Egozi
- PICTURE: Israel's Aeronautics prepares unmanned D-Jet
- Israel's Aeronautics Defense Systems plans to conduct the first flight of its Diamond Aircraft DA42-derived Dominator 2 strategic unmanned air vehicle in May, while first details have emerged of its work to also adapt the Canadian company's D-Jet very light jet for unmanned applications.
- Powered by two TAE Centurion diesel engines, the composite DA42 can be equipped with a variety of payloads for surveillance applications. **Aeronautics president Avi Leumi believes the use of a certificated twin design will shorten the process for the company to secure approval to fly the UAV in civil airspace.** He reveals that Elbit Systems and Israel Aerospace Industries had also sought to negotiate with Diamond on a possible co-operation agreement, but says: "We managed to sign the contract and we believe in the potential of this special UAV."
- Leumi, meanwhile, confirms that Aeronautics is currently converting a D-Jet VLJ in Canada for unmanned missions, but further details have not been released on the project.

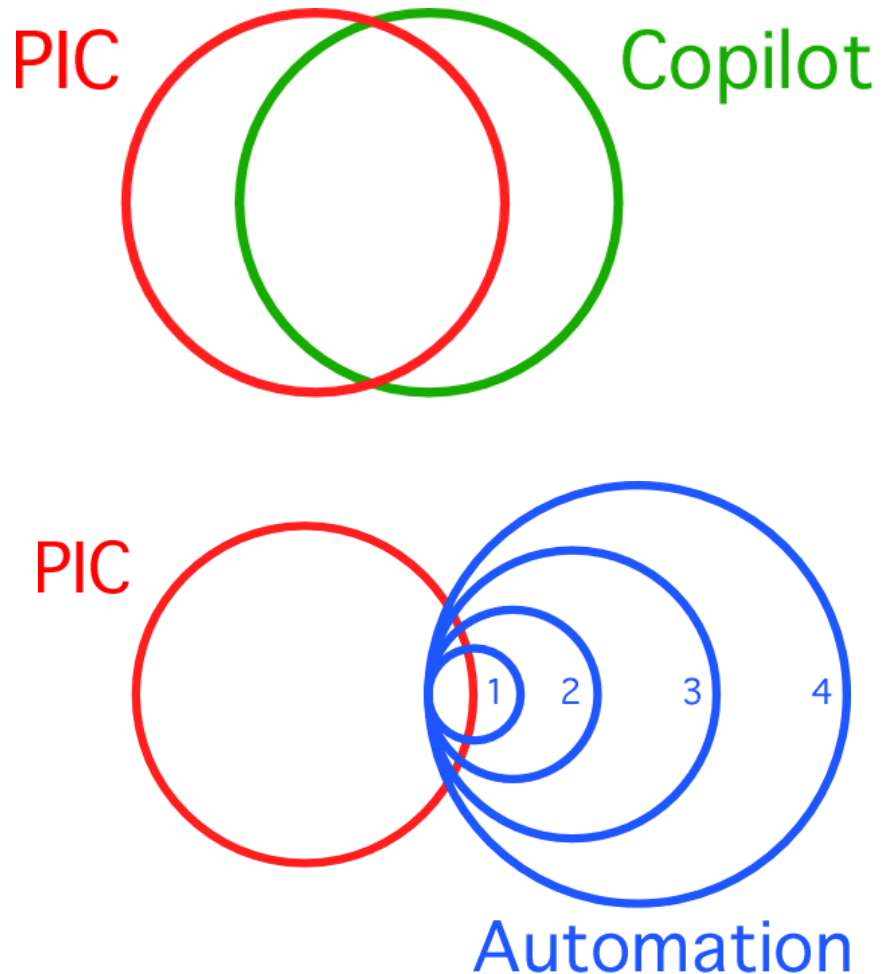


Safe Transition From Piloted To Autonomous?

- UAV Manufacturers and Operators Want Unrestricted UAS Operations Yesterday
 - So far, low energy (low mass, speed, fuel, altitude) has helped, but demands are growing.
- Currently, Even the Most Sophisticated Military UAVs Are Too Unreliable and Inflexible. Are Unable to Operate Freely in a Civilian Airspace
- Is there an Intermediate Step?
 - The PAV could bridge between piloted and automated flight.
 - By having a pilot in command, the automation can do what it does best, helping with the pilot's workload and providing backup.
 - Having the opportunity for long-term operations under real conditions allows for safer trials and debugging, as automation assumes an ever greater role.

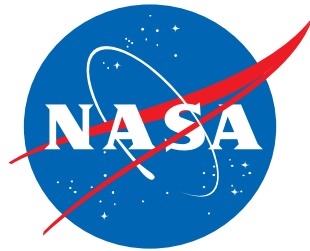
Safe Transition From Piloted To Autonomous?

- Clearly Two Pilots Improve Safety by Not Having Identical Failure Modes
- Initially, Automation Will Have a Small benefit
 - Far less able than a pilot.
 - As generations develop, safety benefits will increase.
 - There may come a day when the automation is more able than a Co-pilot.
- The Key Is to Introduce the Technology Where Benefits Are Immediate, With Minimal Risk
 - Simple aircraft, single pilot operations (GA).



Safe Transition From Piloted To Autonomous?

- As Experience and Capabilities Develop, the Automation Can Expand Scope of Operations
 - Inform human factors design for ground stations operating RPVs. (similar situational awareness needs)
 - Expand single pilot operations to air taxis, business jets, eventually airliners.
 - Hasten, not slow acceptance of autonomous UASs.
- Similar Approach Taken In Capstone, UPS Self Separation
 - Limit risk, try it out, work out the kinks, roll it out when ready.



End of Presentation